

that the tensile stresses at the concrete-adhesive interface, as well as at the FRP-adhesive interface, are highly dependent on the groove dimensions and control the mode of failure of near surface mounted FRP bars and strips. They recommended widening of the groove to minimize the induced tensile stresses at the concrete-epoxy interface and increase the debonding loads of NSM bars. A mathematical model to find the development length of NSM FRP bars is presented along with design charts correlated to experimental results.

2.4 Fatigue of Concrete, Prestressing Strands and CFRP

To properly assess the resistance of a structure or bridge against cyclic loading, the fatigue characteristics of the constituent materials should be assessed. For most materials there exists an endurance limit, an alternating maximum stress which a material can withstand for an infinite number of cycles. Cumulative damage models are the most effective way to assess fatigue degradation of materials within a structure, but these models are beyond the scope of this report. Through experimental testing, the fatigue resistance of materials has been defined using stress ratio versus number of cycle curves, or S-N curves, which offer fatigue life predictions when the stress ratio and other parameters are known.

The fatigue resistance of concrete was first studied extensively when reinforced concrete began being used to construct railroad bridges. Defining $S = f_{\max} / f'_c$ and $R = f_{\min} / f_{\max}$, Aas-Jacobsen (1970) defined an equation for fatigue of concrete under compression-compression cyclic loading:

$$S = 1 - \beta(1 - R)\log_{10} N \quad (2.1)$$

where $\beta=0.064$ and N is the number of cycles to failure.

The performance of concrete under tension-tension cyclic loading is less known (Ahmad 2004). Saito and Imai (1983) found that there is no endurance limit for concrete in tension under